Radio Editors of magazines and newspapers are hereby given permission to reprint in whole or in part, with proper credit to the Aerovox Corporation, the contents of this issue of the Aerovox Research Worker.

the AEROVOX Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

VOL. 11, NO. 6 JUNE, 1939 50c per year in U.S.A. 60c per year in Canada

A. R. SATULLO

# A Guide to the New Tubes

## PART 1

*By the Engineering Department, Aerovox Corporation*

IT has been difficult for servicemen, experimenters and others to keep up with the constant stream of new tubes. At present there are approximately 400 receiving tubes. Many of these are similar in characteristics and differ only in physical dimensions or mechanical construction. Thus there are many different tubes which might be used for a given service, yet each having its special advantages. This article aims to clarify the situation and to classify the new tubes. For the purpose of this article a "new" tube is one which is not described in the current technical manuals available to servicemen, such as the RCA Technical series RC-13 or the Raytheon Data Book or the Sylvania Technical Manual. Thus it includes most tubes issued during the last twelve months.

New tubes may be divided into several groups or classes, each group having its distinct advantages or special applications. The trend is toward greater compactness, increased efficiency at ultra-high frequencies, lower filament current and improved mechanical construction. The 1.4 volt series, the G-tubes, the single-ended tubes, the 300 ma. series, the 150 ma. series, the loktal tubes, the bantam or "dwarf" tubes, the junior bantams and the acorns are some of the classes into which the new tubes may be divided. Since some tubes belong at the same time to more than one class, full information on all tubes mentioned in this article will appear in numerical and alphabetical order at the end of the article. This compilation is as complete as it could be made. It contains descriptions of many tubes which are made by one or more of the smaller manufacturers only.

### TYPE NUMBERS

The type number itself gives considerable information regarding the purpose and construction of a tube. These numbers are now assigned by the RMA according to a standard code. The symbol, or type number, consists of a number or group of numbers indicating the filament voltage, followed by a distinctive letter, and ending with the number of useable elements in the tube. The filament voltage is rounded off to the next lower even volt except in the case of the 2.0 volt battery tubes which are indicated by 1 so as not to confuse them with the 2.5 volt a.c. tubes. The assignment of the distinguishing letter was started at the beginning of the alphabet for amplifier and detector tubes and at the end of the alphabet for rectifier tubes. Since then the two have met and it has become necessary to employ two letters for some tubes.

With the introduction of the glass equivalents of metal tubes, the symbol acquired the suffix G. At present there are many G-tubes which have no metal equivalent. Thus the suffix G now indicates a glass tube with an octal base. As a general rule the characteristics of G-tubes are the same as those of their metal equivalent, if such equivalent exists, except for the inter-electrode capacitances and the shielding properties.

Some of the G-tubes have been made with a smaller tubular bulb. These are known as "dwarf" tubes, "Bantams" or "Tom Thumbs." Such tubes are indicated by a T added after the G. Their characteristics are similar to the corresponding G-tube. Thus the 6K7, 6K7G and 6K7GT all represent tubes with the same characteristics but the 6K7 is a metal tube, the 6K7G a glass tube with dome-shaped bulb and octal base, the 6K7GT a glass tube with a tubular bulb and the same octal base. This tube is also equivalent to the old 78 which has a six-pin base.

The loktal tubes can at present be recognized by their filament voltages; symbols starting with 7 represent loktal tubes. The 35A5, 1231 and 1232 are the only other loktal tubes.

AEROVOX PRODUCTS ARE BUILT BETTER

Printed in U. S. A.

Copyright 1939 by Aerovox Corporation

Some single-ended tubes (with the grid connecting to a base pin) have been given a symbol consisting of that of the equivalent double-ended tube with an S added before the distinguishing letter. For instance, 6K7 and 6SK7, 6F5 and 6SF5. Generally, symbols containing two letters, the first of which is an S, indicate single-ended tubes with characteristics resembling the tube indicated by that symbol when the S is removed. In this case the tubes are not exactly equivalent, the 6K7 being less efficient than the 6SK7 as an amplifier.

## BASES

There are, at present, seven different kinds of bases used for receiving tubes, excluding the specials such as the acorns and Junior Bantams. These are the 4-pin, 5-pin, 6-pin, small 7-pin, large 7-pin, octal and loktal bases. The pin numbering has been standardized as follows: When the tube is held upside down with the filament pins toward the observer, the left filament pin is number one; the other pins are counted clockwise ending with the other filament pin. In the case of octal or loktal bases the counting is clockwise beginning at the key. The key is then between pins 1 and 8.

Tables and data sheets furnished by the manufacturers generally refer to the base diagrams by a symbol such as 6-D or 8-H, etc. These symbols have also been standardized. Therefore any given symbol always stands for the same base diagram regardless of the source of information.

## PHYSICAL SIZE

The glass or metal envelopes come in several standard sizes, each size being indicated by a symbol. A knowledge of bulb and shell sizes is useful to all those who occasionally have to make layouts or attempt to get a given number of parts within the smallest possible space.

The ST bulb is of the well-known dome shape; it comes in three main sizes of different maximum diameters. There are small variations in overall height for different tubes of the same main size. The ST-12 bulb has a maximum diameter of 1-9/16 inches; the overall height varies from 4-1/8 to 4-17/32 inches. The ST-14 bulb has a maximum diameter of 1-13/16 inches, while the overall heights vary from 4-5/8 to 5-1/32 inches. The ST-16 bulb has a maximum diameter of 2-1/16 inches and an overall height of 5-3/8 inches.

The T-bulb is a tubular glass bulb such as the one used for the old 199, the newer bantam tubes, the loktal tubes and the 1.4 volt battery tubes. They are tubular bulbs of three different diameters and in different lengths for each diameter.

The T-7 and T-8 bulbs have a maximum diameter of 1-1/16 inches while the overall height is 2-5/8 inches for the T-7 and 3-5/16 inches for the T-8 bulb.

Battery tubes and Bantam tubes are enclosed in T9-A, T9-B, T9-C, T9-D or T9-E bulbs. The first three have a maximum diameter of 1-3/16 inches and the last two a maximum diameter of 1-5/16 inches. Their overall heights are: T9-A, 4-3/16 inches; T9-B, 4 inches; T9-C, 4-5/16 inches; T9-D, 3-5/16 inches; T9-E, 3-5/16 inches.

The loktal tubes come in bulbs T9-F, T9-G or T9-H. All of these have a maximum diameter of 1-3/16 inches. The overall heights are: T9-F, 3-5/32 inches; T9-G, 2-25/32 inches; T9-H, 2-5/16 inches. Note that all these are smaller than the smallest "bantam".

The metal shells all have a maximum diameter of 1-5/16 inch except the 10A-2 shell (6L6) which has a maximum diameter of 1-5/8 inch. The overall heights are: 8A-1, 3-1/8 inches; 8A-2, 2-5/8 inches; 8B-1, 3-1/4 inches; 8C-1, 1-5/8 inch; 8G-1, 2-5/8 inches; 8G-2, 3-1/8 inches; 10A-2, 4-5/16 inches.

## 1.4 VOLT BATTERY TUBES

This line of tubes was designed for greater economy of battery consumption and for use with a single cell as filament supply. They are especially useful for portable equipment and their development made the new portable receivers possible.

The voltage amplifier tubes and one of the smaller power tubes require but 50 ma. filament current while there are four larger power tubes, which require 100 ma. filament current. They are housed in the T9-B and T9-C envelopes. Some of the tubes are now available, in the bantam version, in a T9-D or T9-E envelope. The complete line now includes two pentagrid converters, several triodes, a diode-triode, an r.f. pentode, power output pentodes and a class B twin triode.

To this group belong the following: 1A5G, 1A7G, 1B7G, 1C5G, 1E4G, 1G4G, 1G6G, 1H5G, 1N5G, 1P5G, 1Q5G and the bantams: 1A7GT, 1D8GT, 1H5GT, 1N5GT and 1Q5GT.

## 6.3 VOLT G-TUBES

There are still some new ones in this series which are described in the list; they are: 6P5G, 6AC5G, 6AD5G, 6AD6G, 6AF5G.

## SINGLE-ENDED TUBES

The small size of parts used in ultra-high-frequency receivers has made grid caps on tubes a disadvantage. The grid lead often presents a real problem since it has to be shielded and should not add any capacity to the circuit. At the same time it has to be flexible which makes its capacity and inductance variable. New tubes were brought out with the grid connected to a base pin so as to allow for shorter leads in the external circuit. Internal shielding is used to prevent electro-static coupling between the grid and the other elements.

There is a 6-volt and a 12-volt series of single-ended tubes. Their characteristics are not exactly equivalent to the corresponding double-ended tubes. Replacing the old tubes by the new ones will probably result in a circuit that works but the sharpness of tuning and the gain will be increased in the case of r.f. pentodes. This may or may not be desirable.

## LOKTAL TUBES

This new series of tubes offers all of the latest improvements. They are of the loktal construction (described in the May issue under the 1231, 1232) and are single-ended and smaller than the bantams. In addition, the tubes have a nominal filament rating of 7 volts. The old 6.3 volt tubes are being used in household receivers as well as automobile receivers. Some manufacturers prefer to run their tubes at a very low filament potential—sometimes as low as 4.8 volts. These same tubes are also subjected to occasional filament potentials of 8 volts and even higher in an automobile receiver. It is to reduce this range of operating voltages that the 7-volt rating was introduced. These tubes can still be operated at 6.3 volts and in parallel or series with similar 6.3-volt types. The 7-volt rating corresponds to 130 volts line potential; then at 117 volts, the tubes run on 6.3 volts.

## BANTAM TUBES

The ever-increasing demand for smaller receivers is responsible for smaller tubes. Some of the familiar tube types have been made available in a short tubular bulb equipped with an octal base with a metal ring. Wherever the base diagram indicates a shell connection for the equivalent metal tube, that pin is connected to the base ring on the bantam.

A special series of bantams with ceramic bases is manufactured by Hytron. They carry the suffix GTX

instead of GT. These tubes have a wide metal base ring connected to pin number 1. When complete shielding is desired a metal shield can be slipped over the tube and connected to the base ring. The shield does not require a base. Thus these tubes can be used as replacements for metal tubes as well as glass tubes.

### 300 MA SERIES

AC-DC receivers, having all tube filaments in series, have been equipped with tubes of different filament voltages but all requiring the same filament current. This series has been extended by several new tubes such as the 12B8GT, 32L7GT which are used in the latest "micro-sets".

### 150 MA SERIES

Reducing the power consumption and the generation of heat is one of the aims in ac-dc receiver design. This new series, requiring only half the filament current and half the power of the old tubes, will result in receivers which can pass the Underwriters regulations. The 6.3-volt tubes of this series are also useful for automobile receivers or other equipment where power is a factor. Most of the 7-volt tubes are also 150 ma. tubes (at 6.3 volt); other members of the series are the 50L6GT, 70L7GT, 25Z6GT, etc.

### JUNIOR BANTAMS AND ACORNS

For extremely compact equipment, Hytron makes three "Junior Bantam" tubes for operation on 1.25 volts (a single cell). They are, the HY113, HY115 and HY125. These compact tubes measure 2.19 inches overall with base, 1.65 inch without base; the maximum diameter is 0.700 inch. A special small 5-pin socket is employed.

The same company also manufactures two special ultra-high-frequency triodes. They are glass tubes are very small dimensions and with an octal base. Both the grid and plate are brought out to caps on top of the tube. The HY615 is for 6.3-volt operation (see May RESEARCH WORKER); the HY114 is for 1.4-volt operation.

Finally, a new set of acorns for 1.4-volt is provided by RCA for ultra-high-frequency use or still more compact construction. These, the 957, 958 and 959 have the same dimensions as the older acorns, the 954, 955 and 956.

### LIST OF TUBES

In the following list abbreviations are used in order to present the most information within a limited space. Practically all of these are self-explanatory but for the benefit of those who may not be familiar with them, their meanings are given here.

Ef, filament voltage; Eg, grid voltage; Eg1, Eg2, etc. voltage on grids number 1, 2, etc. as counted from the cathode to the plate, Ep, plate voltage. If, filament current; Ig, grid current; Ig1, Ig2, etc., current of the respective grid circuits; Ik, cathode current; Ci, input capacitance; Cgp, grid-plate capacitance; Co, output capacitance. Rp, plate resistance; Gm, transconductance; mu, amplification factor; Rc, bias resistor; RL, load resistance; PO, power output; NC, no connection.

For further compactness, the units are not mentioned each time in the ratings and characteristics. All currents are given in milliamperes except filament currents which are in amperes. All potentials are in volts, all powers in watts, Gm in micro-mhos, Rp in megohms or ohms (if the number is greater than 2 the units are ohms), inter-electrode capacitance in micro-microfarads.

1A5G, a power output pentode capable of delivering a maximum output of 0.115 watt at 7% total harmonic distortion. It is a glass tube with a T9-B bulb and an octal base. Characteristics: Ef, 1.4; If, 0.05; Ep, 90; Eg2, 90; Eg1, -4.5; Ip, 4.0; Ig2, 0.8; Rp, 0.3; Gm, 850; RL, 25,000; mu, 255; PO, 0.115. If the tube is operated, self biased from a 90 volt battery, the maximum power output at 10% total harmonic distortion is 0.100 watt. This condition is recommended. Base connections: 1, NC; 2, F+; 3, P; 4, G2; 5, G1; 7, G3 and F-; 8, NC.

1A7G, 1A7GT, a pentagrid converter. The regular tube is built in a T9-C bulb, the bantam in a T9-E bulb. Characteristics: Ef, 1.4; If, 0.05; Ci, 7.5; C (G4 to P), 0.40; C (G2 to G4) 0.25; C (G1 to G4), 0.12; C (G1 to G2), 1.5; Co (osc), 4.0; Co (mix), 10.0; Ci (osc), 3.2; Ep, 90; Eg4, to F-; Eg3g5, 45; Eg2, 90; oscillator grid leak, 0.2 meg.; Ip, 0.55; Ig3g5, 0.6; Ig2, 1.2; Ig1, 0.035; Ik, 2.40; Rp, 0.6; conversion conductance, 250; at -2.0 volts conv. cond. is 50; at -3.0 volts, 5. Base diagram 7Z, same as 1C7G, 1D7G.

1B7G, pentagrid converter with double the filament current and higher conversion conductance than the 1A7G. Characteristics: Ef, 1.4; If, 0.1; Ep, 90; Eg3g5, 45; Eg2, 90; Eg1, to F-; Ip, 1.5; Ig3g5, 1.3; Ig2, 1.6; Rp. 0.35; conversion conductance, 350. Base diagram 7Z, bulb T9-C, the same as 1A7G.

1C5G; a power output pentode capable of delivering about twice the power of the 1A5G. Characteristics: Ef, 1.4; If, 0.1; Ep, 90; Eg2, 90; Eg1, -7.5; Ip, 7.5; Ig2, 1.6; Rp, 0.115; mu, 180; Gm, 1550; RL, 8000, PO, 0.24 at 10% total harmonics. Employing self-bias of 7 volts and operating from a 90-volt battery with a load of 9000 ohms the output is 0.2 watt. Bulb T9-B, base diagram 6X; both the same as for 1A5G.

1D8GT, a complete audiosection, diode triode and output pentode. Ef, 1.4; If, 0.1; Characteristics of pentode: Ep, 90; Eg2, 90; Eg1, -9; Rp, 0.2; Gm, 925; Ip, 5; Ig2, 1; RL, 12000; PO, 0.2 at 10% total harmonic distortion. Characteristics of triode: Ep, 90; Eg. to F-; mu, 25; Rp, 43500; Gm, 575; Ip, 1.1. The tube is enclosed in a T9-C bulb and fitted with an octal 8-pin base. Base diagram 8AJ: 1, NC; 2, F+; 3, Pp; 4, G2p; 5, G1p; 6, Pt, 7, F-; 8, diode plate; cap, Gt.

1E4G, a general purpose triode. Characteristics: Ef, 1.4; If, 0.05; Ci, 2.4; Cgp, 2.4; Co, 6.0; Ep, 90; Eg, -3; Ip, 1.5; Rp, 0.017; Gm, 825; mu, 14. At zero bias: Ip, 4.5; Rp, 0.011; Gm, 1325; mu, 14.5. Bulb, T9-B; base diagram 5S, same as 1H4G.

1G4G, a general purpose triode. Characteristics: Ef, 1.4; If, 0.05; Ep, 90; Eg, -6; mu, 8.8; Rp, 0.0107; Gm, 825; Ip, 2.3. Bulb T9-B, base diagram 5S, same as 1H4G.

1G6G, a class B twin-triode amplifier. Characteristics as class B power amplifier: Ef, 1.4; If, 0.1; Ep, 90; Ip (peak per plate), 20 (max). Typical operation: Ep, 90; Eg, 0; eff. grid circuit impedance per unit, 516 ohms; pk. signal voltage grid to grid, 48; Ip for zero signal (two units), 2; Ip max. signal (two units), 14; Ig, pk. per unit, 6; RL plate-to-plate, 12000; PO 0.675 at 5%.

Characteristics for each triode unit: Ep, 90; Eg, to F-; Ip, 1; Rp, 0.045; Gm, 675; mu, 30. Bulb, T9-B; base diagram, 7AB, same as 1J6G.

1H5G, 1H5GT, a high-mu triode and single diode. Characteristics: Ef, 1.4; If, 0.05; Ci, 0.35; Cgp, 1.1; Co, 4.0; Ep, 90, Eg, to F-; Ip, 0.15; Rp, 0.24; Gm, 275; mu, 65. The diode plate is located at the negative end of the filament. Bulb T9-C for 1H5G and T9-E for 1H5GT; base diagram 5Z: 1, NC; 2, F+; 3, P; 4, NC; 5, diode plate; 7, F-; 8, NC; cap, G.

This list of tubes will be continued in the July issue of the Research Worker.

# Indispensable...

● With more pages, more items, more choice than ever before, the new 1939-40 AEROVOX catalog is now to be found among the working tools of leading engineers, designers, production men, amateurs and experimenters.

Be sure you have this catalog at hand for constant reference. If not, drop us a line TODAY, and a copy will be sent to you immediately.

Meanwhile, see your local jobber regarding the many new AEROVOX items featured in our 1939-40 catalog.

## AEROVOX CORPORATION

*New Bedford, Mass.*

**Sales Offices in All Principal Cities**